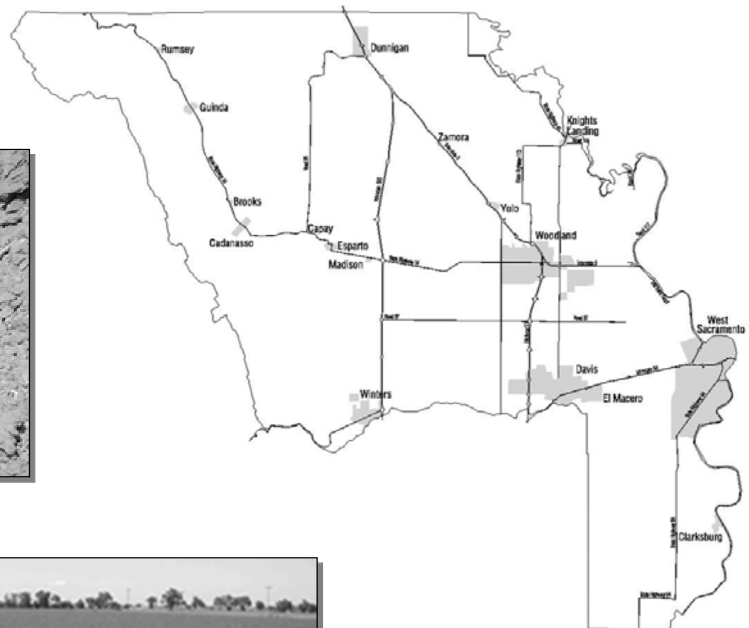
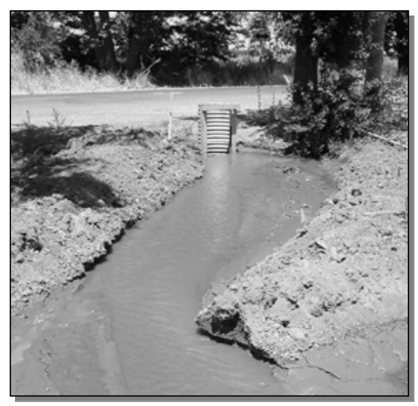
Final Report

CALFED Water Use Efficiency Program

Yolo County Resource Conservation District
Pilot Program 2001





May 2002

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Executive Summary

The Yolo County Resource Conservation District undertook a one-year pilot program funded by the CALFED Water Use Efficiency Program (WUEP) from December 2000 through December 2001. CALFED staff asked the District to 1) trial and evaluate techniques for assessing the efficacy of several water conservation practices such as tailwater retention ponds, cover crops and filter strips, irrigation evaluation techniques and sediment traps and 2) conduct a survey of water suppliers and conservation professionals regarding successful techniques and partnerships for promoting on-farm water use efficiency.

> The **CALFED Bay-Delta Program** is a consortium of State and Federal agencies with regulatory or management responsibility in the Bay-Delta that are working together to solve the San Francisco Bay-Delta region's problems regarding environmental quality and water supply in a balanced way that offers benefits for all interests.
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> The **CALFED Water Use Efficiency Program** is focused on water use efficiency issues in the CALFED region, working with the recognition that implementation of efficiency measures occurs mostly at the local and regional level. Their role in water use efficiency is to offer support and incentives through expanded programs to provide planning, technical, and financial assistance. The WUEP is also establishing Quantifiable Objectives for regional water conservation and monitoring progress toward those objectives.

The District's interest and intent in participating in the Pilot Program was to initiate more rigorous analysis of the assumed water quality benefits of practices it has long promoted: especially those of tailwater ponds, sediment traps and winter cover cropping. The actual water quality improvements associated with those conservation techniques had never been rigorously quantified. In light of the changing regulatory climate regarding farm runoff water quality, this information could prove particularly useful for informing 1) regulators of acceptable and measurable water conservation techniques that can be used to meet their goals, and 2) farmers and water managers of proven tools that they can employ in their desire to best manage the water under their control. In general, the District provides technical support for on-farm conservation with its partner the USDA Natural Resources Conservation Service (NRCS). As such, the District has the opportunity to work closely with local farmers and agricultural industry and is familiar with the stresses and realities of agricultural operations and the families that run them. The District is committed to exploring and promoting means of voluntary compliance without direct regulation that allow farmers to continue their business while properly managing public resources such as air, water, and wildlife. While this Pilot Program only provides a single year of analysis for a limited set of these practices, the District will extend this research through other CALFED (Ecosystem Restoration Program) funding.

In this Pilot Program, tailwater ponds and sediment traps entrained as much as 90% of the mass of suspended solids carried in the irrigation tailwater passing through them. Proper design and maintenance were important factors influencing the efficacy of the ponds studied. Most of the traps and ponds studied provided some nutrient capture from irrigation water runoff primarily during early season irrigations, although that aspect of their function definitely bears further study. As nutrients are either soluble or attached to clay particles in the water, means to entrain those finest soil particles that do not easily fall out of suspension without longer residence times than those provided in the subject ponds and traps need to be explored.

The winter cover crop study demonstrated runoff flow attenuation and reduced concentrations of suspended solids in runoff. Future study of the winter runoff attenuation and water quality impacts relative to cover crop planting date and cover crop growth stage would help to gauge the most effective application of this technique. In the context of a processing tomato rotation in the Sacramento Valley, the costs of planting and incorporating a winter cover crop are typically less than the income generated from the slightly (5-7%) increased yields associated with the practice. Since initiating a cover crop runoff and yield impact study in processing tomatoes with UC Cooperative Extension (UCCE) in 1997, we have observed a gradual increase in the practice in Yolo County. In our estimation, a new practice probably requires more attraction to the average grower than simply "breaking even" to merit the inconveniences of equipment and task changes.

The water conservation professionals surveyed (8 responses out of 27 surveys sent) as part of this Pilot Program identified several existing tools for promoting on-farm water use efficiency. Of highest regard were local mobile irrigation lab programs and local workshops and publications demonstrating and detailing techniques that farmers can employ. While UCCE and NRCS provide excellent information and technical resources, the most productive agency collaboration appears to be that between local water suppliers and Resource Conservation Districts. In two of the cases surveyed, the RCD and water district function practically as one organization. In a third, multiple water districts each provide funding to an RCD to manage and implement a mobile lab for their water customers. Most regions of the state include significant numbers of farmers who rely in part or in whole on groundwater and do not depend upon a water district for their irrigation water supply. Water use efficiency is compelling for them at the very least because of increasing energy and, therefore, pumping costs. A different source of support for a local water use efficiency program such as a mobile irrigation lab will need to be identified for those regions and farmers. While CALFED may not be fully accepted as a partner by members of the agricultural community, survey respondents suggested that CALFED support of local work local work, alternatives to regulatory solutions, and effective response to water supply concerns could improve that relationship.

While the District considers the information gathered through the Pilot Program to be useful to CALFED in its aim to promote locally-led, on-farm water use efficiency programs, the Pilot Program has also provided an excellent opportunity for the District to refine its on-farm monitoring program and understanding of potential collaborations for promoting water use efficiency in Yolo County.

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Introduction

This report discusses the results and findings from a one-year pilot project funded by the CALFED Water Use Efficiency Program from December 2000 through December 2001. The Yolo County RCD was presented with four tasks that were initially modified after the program was funded to accommodate delays associated with the contract development process. Those tasks were:

- Research monitoring techniques and their costs for assessing the efficacy of several conservation techniques such as: tailwater retention ponds, cover crops and filter strips, irrigation evaluation techniques and sediment traps;
- Survey entities around the State that work with water delivery and on-farm water use efficiency to assess potentials for local partnerships and possibilities for improving the CALFED Ag WUE Program's delivery and efficacy for promoting on-farm water use efficiency;
- Implement and evaluate water use efficiency techniques on local farms, including:
  - Five sediment traps intercepting runoff from row crop furrow-irrigated fields before it drains into local waterways;
  - Five pre-established tailwater return systems;
  - Winter cover cropping on an annual crop (processing tomatoes) field;
  - Irrigation evaluation and soil moisture sensing techniques on three furrow-irrigated fields
- Communicate pilot program results through field meetings, literature and a final report.

The District was selected for this pilot program because of its history as an innovator in on-farm water quality improvement techniques, especially those employing native perennial grasses, wetland plants, shrubs, and trees. The District devoted at least two staff persons to the program, with a peak of activity including a full-time UC Davis Agricultural Engineering graduate student through the summer months. The District also made liberal use of the assistance of CALFED Water Use Efficiency Program staff, most notably Arturo Carvajal, who also assisted in the development of this report. Larry Schwankl of the University of California Cooperative Extension program also provided valuable direction at the early stages of the project. The techniques employed and research questions raised for the program were partly informed by previous work undertaken as part of a Total Resource Management Challenge Grant funded by the US Bureau of Reclamation from 1994-2000.

The District's intent in taking on the pilot program was to initiate more rigorous analysis of the assumed water quality benefits of practices it has long promoted: especially those of tailwater ponds, sediment traps and winter cover cropping. Before this Pilot Program, District personnel and farmers alike could easily observe sediment captured from farm runoff with ponds and traps and District staff had already documented significantly reduced storm runoff with winter cover crops (Miyao & Robins, 2000). However, the actual water quality improvements associated with those conservation techniques had never been rigorously quantified. Such measurements are critical in assessing the efficacy of and deficiencies (areas for improvement) of those practices that the District and other conservation organizations promote. While this Pilot Program only provides a single year of analysis for a limited set of these practices, the District will extend this research through other CALFED Ecosystem Restoration Program funding.

The following report is divided into sections according to individual conservation techniques monitored (Tasks 1 & 3), and the survey and outreach tasks (2 & 4). Because of the volume of data associated with Task 3, only a portion of the data is included in the body of the report, with the balance included in an appendix.

The **Yolo County Resource Conservation District** covers over 500,000 acres (83%) of Yolo County, with terrain varying from 2,500'-high interior coast range peaks on the far west to valley floor gently sloping across the majority of the county to the Sacramento River on the east. Dominant soils are deep valley alluvium, from clay to sandy loam texture, deposited over time by the flooding of the Sacramento River, Putah Creek on the south, Cache Creek, and other minor drainages. These deep soils support a healthy agricultural economy that generates about $300 million per year in crop revenues.

The District is committed to exploring and promoting means of voluntary compliance without direct regulation that allow farmers to continue their business while properly managing public resources such as air, water, and wildlife. Several of these techniques are presented in the District publication, *Bring Farm Edges Back to Life!*

According to the District's mission statement: "The Yolo County RCD is committed to protecting, improving, and sustaining the natural resources of Yolo County. We promote responsible stewardship by:

Demonstrating conservation practices through cooperative land users,
Educating the public in resource conservation and enhancement,
Providing information and expertise."

The District's lines of business include: education, land treatment, resource assessment, and future planning. The Board consists of four farmers and one landowner, all of whom actively undertake conservation practices on their ranches and work within the community to promote resource conservation.

Conclusion

After a single year of work, Pilot Program results can at least be summarized as observations of likely successes or matters warranting further study. The water conservation techniques examined and implemented in this Pilot Program all have merit as feasible practices for farmer adoption, but the precise nature of their benefits needs further evaluation based on replicated, multiple year studies. The District will implement such a study independent of the CALFED WUE Program over the next three years (through 2004). The survey under Task Two of the Pilot Program also represents more of a "taking off" point than a conclusive result for both the District and CALFED regarding organizational relationships and local tools for promoting on-farm water use efficiency. The District's relationship with Yolo County's primary agricultural water supplier is currently shifting to allow closer collaboration on a variety of programs, potentially similar to those modeled by other RCDs and water districts. While the District considers the information gathered through the Pilot Program to be useful to CALFED in its aim to promote locally-led, on-farm water use efficiency programs, the Pilot Program has also provided an excellent opportunity for the District to refine its on-farm monitoring program and understanding of potential collaborations for promoting water use efficiency in Yolo County.

Below is a summarization of the benefits and limitations observed of the conservation practices employed during this Pilot Program.

Winter Cover Cropping

- For the three measurable storm events in the study, total flow of runoff from the cover crop treatment was reduced by as much as 71% in one storm, but increased by 37% in another. Peak runoff in all comparable events was delayed in the cover crop treatments by 5-20 minutes. Peak runoff flow was reduced by 0-20% in the cover crop treatment in those events as well.

- Average sediment concentration in runoff from two storms was reduced by 17-46%.

- Average nutrient concentration in runoff (Nitrate and Ammonia) was beneficially reduced in one storm event by 43% and 49%, respectively. However, in that same event, higher runoff was observed from the cover crop treatment (a result not consistent with other storms or other cover crop studies), which contributed to higher total volumes of nutrients running off from the cover crop plots, as seen below.

Treatment	Sediment		**Ammonia Nitrogen**		**Nitrate Nitrogen**	
	Avg. Conc. (mg./L)	Total Volume (kg.)	Avg. Conc. (mg./L)	Total Volume (mg.)	Avg. Conc. (mg./L)	Total Volume (mg.)
Cover crop (1)	1.65	0.82 kg.	.004	2.12 mg.	.263	106.46 mg.
Cover crop (4)	1.44	0.38 kg	.0023	0.40 mg	.398	116.86 mg
Fallow (2)	1.69	0.39 kg	.011	7.18 mg	.419	36.69 mg.

Fallow (3)	0.94	0.41 kg.	.042	8.52 mg.	.738	89.92 mg.

Per acre cost of cover crop installation and incorporation for this trial was:

Item	Detail	Per acre Cost
Materials (seed)	45# common vetch @ $0.50/# + 15# Dundale pea @ $0.25/#	$26.25
Equipment and Labor	Ground preparation, planting and incorporation	$30 - $60
Total		**$56 - $86**

SedimentTraps

- The amount of sediment carried in irrigation runoff was made dramatically evident by the rate at which the Pilot Project traps were filled with sediment (many in two irrigations). Cooperating farmers were able to see the benefits of having the sediment traps because of the reduction on sediment collected in on-farm main drain ditches. They were surprised by the results and expressed heightened interest in continued use of sediment traps on their farms.

- All of the sediment traps in the Pilot Program captured sediment, but none were large enough to capture all of the "capturable" sediment (especially non-fines) leaving the different fields studied. Percent Sediment captured ranged from –13%, for a full trap actually contributing sediment to tailwater, to 98%, for a newly dug trap catching first irrigation water, in this study. Traps full of sediment increased sediment concentration in runoff until they were excavated, after which they again entrained sediment. Mid-season percent sediment capture ranged between 33-55% (by mass) in most ponds.

- Nutrient capture was inconsistent among all the traps observed except during the very early season irrigations, when concentrations of sediment and Nitrogen (Nitrate & Ammonia) in runoff were high. Only at that time did traps appear to consistently reduce Nitrogen concentrations in runoff.

- The apparent benefits of even undersized traps such as those employed in this Pilot Program was clear. To achieve maximum results, however, they must be monitored and maintained. Their function decreased over time as they filled with sediment, and did not function at all when filled completely with sediment. Proper trap design and construction will ease maintenance requirements. If space and field configuration permit, a sediment trap should be sized to capture all of a given season's sediment without completely filling. Further study will provide better information regarding proper trap capacity and sizing.

- Limitations to trap design and siting include location of field bottom roads, lack of space between field bottom and drain, height of the drain relative to the field, concern about backing water into the furrows, and height of downstream drains.

- The longitudinal slope of the field tail ditch slope appeared to be an important factor affecting field erosion. While we rarely observed significant erosion in furrows themselves, we did see it consistently in their intersections with the tail ditch (typically a 6"-12" drop that induced headcutting into the furrow), and along the length of the tail ditches, especially those cut deep with steep slope. Careful or gradual tail ditch construction would likely have reduced the amount of soil erosion on the fields observed.

- In tail ditches, canvas dams served as a remedy to this problem, slowing the runoff and collecting sediment that extended the utility of the sediment traps (i.e., the traps filled more slowly, thereby functioning longer). The use of canvas dams along the tail ditch slows the erosion rate, providing miniature sediment traps. This has the added benefit at the end of the irrigation season of leaving the collected soil nearer to its origin than a sediment trap would.
- Trap installation cost was approximately \$600 - \$1000, including cost of flashboard risers and culverts (\$200 - \$600 depending on the site) and excavation (approx. \$200 - \$500 depending on site).

Tailwater Ponds

- Because of their much larger capacity, none of the tailwater ponds studied filled with sediment during the study period. In fact, we found them difficult to monitor for single-year volume changes because the volume of sediment captured was so small relative to the ponds' total capacities. Observation of cumulative sediment capture over several years would provide more reliable results.
- % Sediment Capture during the growing season in the ponds studied ranged between 11% and 97%, with one anomalous reading of –39%. Because of their volume or recirculation system, the ponds did not always have measurable outflow, rendering likely sediment capture nearer to 100%.
- In the one tailwater pond built in combination with a sediment trap, combined % sediment capture was consistently higher, ranging between 46% - 99.7%. Such a configuration ultimately reduces the pond maintenance requirement as the traps capture much of the sediment that would otherwise fill the pond more rapidly over time. This allows other beneficial uses of the pond such as wildlife plantings.
- Pond construction cost depends on pond size and type of return system (if included). The range of costs found in the Yolo County area for ponds with capacities between 1.5 and 4 acre-feet is \$4,000 - \$12,000 for pond and inlet/outlet structures. Addition of a return system with 1800' of pipe typically runs between \$10,000 and \$16,000, with much of the price variation dependent upon pump size. Addition of native vegetation on the area around the pond would add an additional \$1,000 - \$3,000 for material, labor, and irrigation system.

Irrigation

- It was observed that flow from gated pipe systems was more difficult to manage than siphon systems on the subject fields of this study.
- The quality of irrigation practices varied widely between the fields studied. While some irrigators had their technique refined to match the field and could carefully control water

application and runoff, other irrigators with apparently inferior management practices seemed to be a primary cause for excess runoff, resulting in additional soil erosion.

- Short of water delivery system changes, costs for improved irrigation management are primarily those of management time and education for the farmer and his/her irrigation crew. Costs for soil water sensing devices are included in the table below.

Monitoring Costs

A summation of the costs, quality, and ease of use of the monitoring techniques employed in this Pilot Program and other District programs is included below.

Parameter & Tool	Material Cost	Installation Cost	Data collection time requirement	Quality of data	Ease of use
In-furrow flow					
Flume	$285/ea. for fiberglass RBC flume	½ man/hr per furrow	Very quick if gauge is easily visible (1 min./furrow)	Depends on the number of furrows observed to account for variability. Per furrow information is good.	Installation is time intensive, especially for multiple furrows. Potentially disruptive to furrow & soil
Siphon flow estimation	Container of known volume and stop watch	None	~5 min./furrow. Check periodically during irrigation	Same as above	Simple, but wet.
Bucket sunk in furrow w/ pump and flowmeter	~$400/installation	~2 hours/site	Simple and quick	Accuracy to 0.10 gal. Measures total flows only	Simple
Ditch flow					
Weir	Starting at $50+ depending on size and need for footing	1-2 man-hrs each (more w/ footing/armoring)	Quick with visible gauge. Setup and download time only with datalogger (2 man-hrs.)	High	Easy
Water level sensor (see ITRC publication comparing sensors & dataloggers at www.itrc.org)	$500 - $5000	Stake and wire minimum. May need stand or box for data logger.	Setup and download time for datalogger. 1-2 man-hrs excluding technical difficulties	High—resolution depends on type and quality of sensor	Varies between brands. Software and datalogger can be easy or cumbersome

Parameter & Tool	Material Cost	Installation Cost	Data collection time requirement	Quality of data	Ease of use
Pipe flow					
Propeller meter (8” dia. Pipe)	$770-$1110	$50-$500	Simple	High	Easy
Doppler	$4,000	Negligible	Setup and download time from datalogger—1-2 man-hrs.	High for water with impurities. Less useful for very clean, or well water	Easy
Soil water					
Gypsum block	$5-10/each + $150 meter	One three-block station: 1-2 man/hrs.	Easy with dry access. Messy in wet field. 5 min./station	Measurements are relative soil-water tension only	Relatively easy
Watermark®	$29/each + $275 meter. Blocks can be retrieved and reused if installed with pvc pipe attached	One three block station: 2 man/hrs. & ~$5 (including pvc pipe and glue on each)	Easy with dry access. Messy in wet field. 5 min./station	Good. Measurements in centibars. Less accurate in sandy soils that dry quickly.	Relatively easy
Tensiometer	$100+	1 man-hr.	Easy	Good, but can lose tension if soil dries completely	Easy. Reusable.
Water sampling					
Grab samples	Minimum: cost of mason jar ($1)	None	Depends on site	Good if sample handled according to lab specifications	Depends on site. Small channels or bodies easy. Larger channels awkward.
Automated sampler	$2,500 and up	Depends on site. Minimum installation time is 1-2 man/hrs. w material cost of a stake. Higher cost associated with sampler shelter.	Depends on quality of software. Min. setup and download time 1-2 man-hrs. Sample handling and shipping to lab addnl 2 man-hrs per batch + transport costs	Good if sample handled according to lab specifications	Excellent for collecting samples at odd hours and remote or inaccessible locations. Software and datalogger can be easy or cumbersome

Parameter & Tool	Material Cost	Installation Cost	Data collection time requirement	Quality of data	Ease of use
Lab analysis	See Table 6 on page 35 for range depending on constituent	N/a	N/a	High	N/a
Cardy meter	$250	None	0.5 man-hrs/ sample	Good. Best to "calibrate" with lab results	Straightforward. Can be used for several nutrients
Test strips	As low as $10/kit. Nutrients & pH.	None	0.5 man-hrs./sample	Low	simple
Colorimeter	$1250 including reagents	None	Straightforward	High	Good.

Survey

The water conservation professionals surveyed as part of this Pilot Program identified several existing successful tools for promoting on-farm water use efficiency. Of highest regard were local mobile irrigation lab programs and local workshops and publications demonstrating and detailing techniques that farmers can employ. While UCCE and NRCS provide excellent information and technical resources, the most productive agency collaboration appears to be that between local water suppliers and Resource Conservation Districts. In two of the cases surveyed, the RCD and water district function practically as one organization. In a third, multiple water districts each provide funding to an RCD to manage and implement a mobile lab for their water customers. Most regions of the state include significant numbers of farmers who rely in part or in whole on groundwater and do not depend upon a water district for their irrigation water supply. Water use efficiency is compelling for them at the very least because of increasing energy and, therefore, pumping costs. A different source of support for a local water use efficiency program such as a mobile irrigation lab will need to be identified for those regions and farmers. While CALFED may not be fully accepted as a partner by members of the agricultural community, survey respondents suggested that CALFED support of local work, alternatives to regulatory solutions, and effective response to water supply concerns could improve that relationship.